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USSR REPORT

Construction and Equipment

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Contents

CONSTRUCTION

METHOD FOR ANALYZING, COMPUTING EFFECTIVENESS OF INVESTMENT CYCLE OFFERED

Moscow EKONOMIKA I MATEMATICHESKIYE METODY in Russian Vol 17 No 1, Jan-Feb 81 (signed to press 19 Feb 79) pp 141-156

[Article by M. R. Mazin (Moscow): "Economic Evaluation of Characteristics of the Investment Cycle in the System for Managing Construction"]

[Text] Domestic economics science has been developing the investment-cycle theory intensively in recent years. This is explained by a number of factors: first, by the national economic significance of many of the problems of construction: lengthy construction time and growth in the amounts of uncompleted construction (it is more rapid than the growth in capital investment or in the introduction of fixed capital) lead to the annual "freezing" of billions of rubles. Second, by growth in the cost of the investment programs being executed. Third, by the need to raise the national economy's effectiveness, which is dependent upon skill in evaluating investment from the viewpoint of the long term.

The investment cycle is studied mainly in two of its manifestations--its influence on capital investment effectiveness, and the construction time involved (see [1-10]). Up to this point, scientific research and economic practice have not by far drawn all the conclusions that are required by the modern concept of investment processes. This article proposes a procedure for an economic evaluation of the characteristics of the investment cycle and the effect from reducing the time required for erecting facilities for production purposes, and it also examines questions of improving the practice of computing economic effectiveness in correlation with improvement of the system for managing construction.

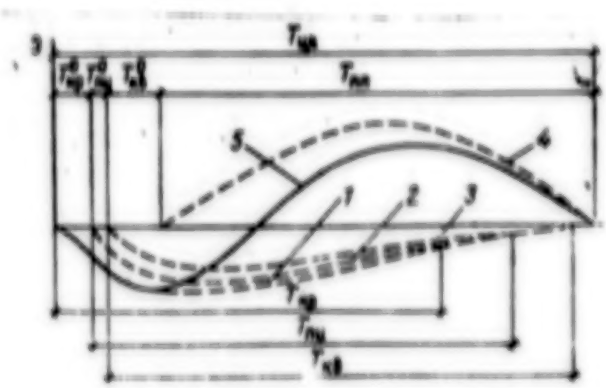
1. Determination of the Duration of the Execution of Investment and the Distribution Thereof by Year of Construction of Facilities

The period from the start of spending for scientific-research development (NIR) and (or) design and survey work (PIR) for the purpose of producing some kind of output until the time it stops bringing in income (the "life cycle" concept for innovations, which is close in content, is found in the literature) is called the investment cycle in this article. The investment cycle can be studied for various outputs (figure 1) or capital facilities (figure 2).* It can also be studied for

*In figures 1 and 2 the scientific-research, design-and-survey and capital expenditures associated with obtaining an individual output or with the construction of an individual facility are indicated with a minus sign, profit with a plus sign.

individual branches of the economy, especially large investment programs. The available statistics allow study only of the investment cycle for capital facilities as a whole.

Figure 1. Elements That Characterize the Investment Cycle of Individual Output:



$T_{HИР}$ is the duration of expenditures on scientific-research work (1--expenditures on NIR).

$T_{ПИ}$ is the duration of expenditures on design and survey work (2--expenditure on PIR).

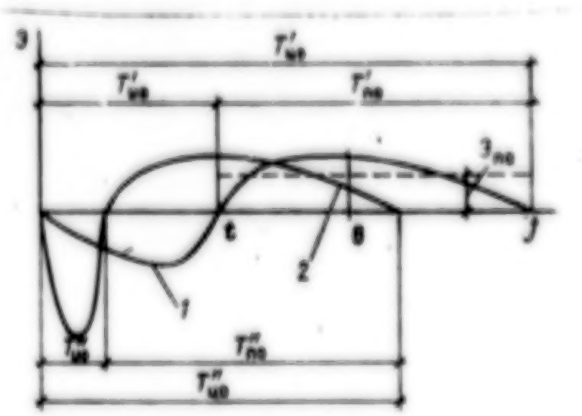
$T_{кв}$ is the duration of the execution of capital investment (3--capital investment).

$T_{ПП}$ is the duration of the receipt of income from the production of output (4--income).

$T_{цп}$ is the duration of the investment cycle (5--an integral curve for "expenditures and profit").

The zero index designates the period of expenditures necessary for the beginning of industrial production of the output

Figure 2. Elements that Characterize the Investment Cycle of an Individual Facility:



T_{uo} is the duration of execution of the investment.

$T_{пo}$ is the duration of receipt of profit from the functioning facility.

$T_{цo}$ is the duration of the investment cycle.

Curve 1 is where $T_{uo}' = 1$.

Curve 2 is where $T_{uo}'' = 2$.

The first element of the facility's investment cycle--the time taken to execute the investment T_{uo} (see figure 2)--is examined below (because of the lack of facility-by-facility statistics on expenditures for NIR and PIR) as the construction period, from the start of realization of the capital investment until the introduction of the facility. We designate $T_{i\lambda} (T_{i\lambda} \equiv T_{uo})$ as the construction period of the facility λ, $\lambda = 1, \ldots, q$, which was introduced in the year i, $i = 0, \ldots, t, \ldots, i + 1\ldots$. In accordance with the practice of discrete planning of investment, we depict the distribution of expenditures by year of construction of the facilities that are introduced in the year i, unlike the case with figures 1 and 2, in the form of polygons and absolutes, since they are examined independently of the cycle as a whole (figures 3 and 4) in this part of this work. For all facilities introduced in the year i, and for capital investment for the year j

$$T_i = \max_\lambda T_{i\lambda}, \quad \sum_\lambda K_{ij\lambda} = K_{ij}, \quad \sum_j K_{ij} = B_i, \quad \sum_i K_{ij} = K_j \tag{1}$$

Construction time is usually considered to be the period of continuous conduct of work (norms for the duration of construction are compiled in accordance with this definition [11]). Consequently, the construction period exceeds construction time by the magnitude of the interruptions in the work at the facilities (the latter was substantial enough in 1958-1968 (the interval for which construction statistics are analyzed below)—10-12 percent of the total number of the facilities being introduced [6]).

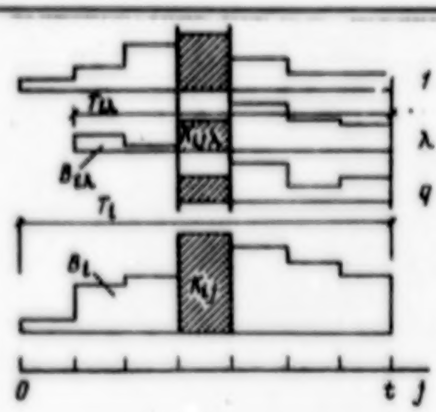


Figure 3. Diagram of the Formation of the "Age" Structure of Total Introduction of Facilities in the Year i on the Basis of the Structures of Individual Facilities λ Introduced:

B_i is the total cost of the facilities introduced during the year i; and

K_{ij} is the capital investment for the year j at facilities introduced during the year i.

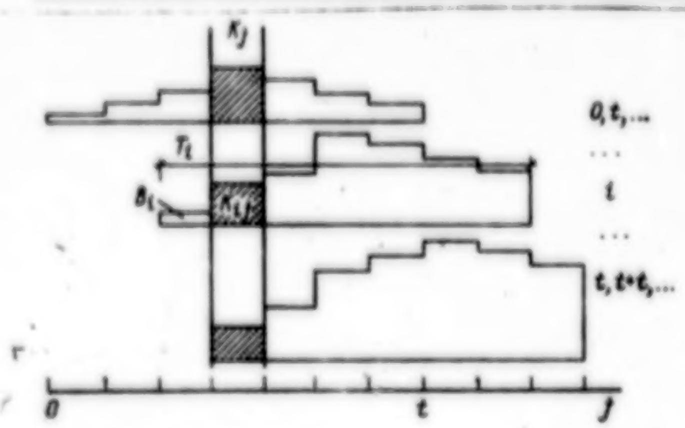


Figure 4. Diagram of the Use of Capital Investment for the year j for Introductions of Facilities in the Year i:

K_j is the capital investment for the years j, B_i and K_{ij}—the same ones shown in figure 3.

Investment in an individual facility, or in a combination of them, which is introduced in the year i is distributed unevenly in time, so the period of "freezing" of investment in construction can be characterized in generalized form as the weighted mean time for the realization of capital investment for separate facilities $\bar{T}_{i\lambda}$ and for a combination of them $\bar{T}_i$

$$\bar{T}_{i\lambda} = \frac{\sum_j K_{ij\lambda}(T_{i\lambda} - j + 0{,}5)}{\sum_j K_{ij\lambda}}, \tag{2}$$

$$T_i = \frac{\sum_j K_{ij}(T_i - j + 0{,}5)}{\sum_j K_{ij}}, \tag{3}$$

where (see figure 3) $K_{ij\lambda}$ and K_{ij} are the investments for the years j, j = 0, ..., T_i, f the separate facilities λ or a combination thereof introduced in the year i.

There is no statistical accounting at present for the values of $T_{i\lambda}$ and T_i and of their weighted mean values. Under certain assumptions the values of T_i and $\overline{\overline{T}}_i$ can be calculated on the basis of data about the value of capital investment and the cost of introduction and of uncompleted construction which are available for the branch of industry [12].

The first assumption is about the stationary state of the value of T_i and of the "age" structure of introduction B_i for the period 1958-1968, for which statistics are known [12], that is:

$$\begin{gathered} T_0 = \ldots = T_i = t, \\ A_0 = \ldots = A_j = \ldots = A_i = A, \end{gathered} \tag{4}$$

where t is the duration (the number of the last year) of the construction period, and A is the vector of the coefficients of the "age" structure of introduction, and the elements of the vector a_{ji} are equal to the fraction of the introduction B_i that is provided through capital investment in the year j, it being the case that

$\sum_j a_{ji} = 1$ for any i.

This assumption is not fundamental. It has been made for simplification of the formal aspect of what has been set forth.

For the year t (which, in accordance with stipulation (4), can be any year of the period being studied) the connection between the initial and the final values of the cost of introduction (B_0 and B_t), capital investment (K_0 and K_t) and uncompleted construction (H_0 and H_t) can be presented in the form of exponential functions of the average annual pace of growth (of b, k and н, respectively) for each indicator

$$B_t = b^t B_0, \tag{5}$$

$$K_t = k^t K_0, \tag{6}$$

$$H_t = н^t H_0. \tag{7}$$

Let us also write an equation of the future investments Б at facilities started in the year t (the residual budget-estimated cost thereof)

$$\text{Б}_t = \text{б}'\text{Б}_0. \tag{8}$$

Stipulation (4) enables a diagram of the use of capital investment and of activation of the introduction to be presented in the form of a matrix $a_{ji}B_i$ (see table 1)*, which consists of parts of the capital investment K_j, equal to the fraction# a_{ji} of introduction B_i that were introduced in the year i.

Table 1

i	j: 0	1	...	t	$t+1$	...	$t+l$	B_i
0	a_tB_0							B_0
1	$a_{t-1}B_1$	a_tB_1						B_1
...	...	...						...
t	a_0B_t	a_1B_t	...	a_tB_t				B_t
$t+1$		a_0B_{t+1}		$a_{t-1}B_{t+1}$	a_tB_{t+1}			B_{t+1}
...				...	...			...
$t+l$				a_0B_{t+l}	a_1B_{t+l}	...	a_tB_{t+l}	B_{t+l}
K_j	K_0	K_1	...	K_t	K_{t+1}	...	K_{t+l}	

The values B_t, K_t, H_t and Б_t can be expressed in terms of elements of the matrix as functions of the introduction, the rates of growth thereof, and of vector A

$$B_t = (a_{0,t} + a_{1,t} + \ldots + a_{t,t})B_t, \tag{9}$$

$$K_t = a_{t,t}B_t + a_{t-1,t}B_{t+1} + \ldots + a_{0,t}B_{t+t}, \tag{10}$$

$$\text{H}_t = B_{t+1}[(a_{0,t} + a_{1,t} + \ldots + a_{t-1,t}) + (a_{0,t} + a_{1,t} + \ldots + a_{t-2,t})b + \ldots + a_{0,t}b^{t-1}], \tag{11}$$

$$\text{Б}_t = B_{t+1}[(a_{t,t} + (a_{t-1,t} + a_{t,t})b + \ldots + (a_{1,t} + a_{2,t} + \ldots + a_{t,t})b^{t-1}], \tag{12}$$

where (9) is the line t of the matrix; (10) is the column t; and (11) is the submatrix (t + 1, t) and (12) is the submatrix (t + 1, t + 1) in table 1, which are singled out by the frame.

*In table 1 the indices i of the fraction a_{ji} are omitted and the indices j are indicated by constants for all j (for the year t) in accordance with stipulation (4).

#Strictly speaking, it should be considered that 90-98 percent of the capital investment is transferred on the basis of the cost of the fixed productive capital (or introduction). Such an accounting was not made because of both the lack of statistics and insignificant influence on the conclusions of this article.

A study of the construction period thus reduces down to a determination of the value t and coefficients of a_{ji}. Let us write, on the basis of (9)-(12), a system of finite-difference equations for the annual increments of the indicators for the consecutive years t and t + 1

$$B_{t+1}-B_t=a_{0,t}(B_{t+1}-B_t)+a_{1,t}(B_{t+1}-B_t)+\ldots+a_{t,t}(B_{t+1}-B_t), \tag{13}$$

$$K_{t+1}-K_t=a_{t,t}(B_{t+1}-B_t)+a_{t-1,t}(B_{t+2}-B_{t-1})+ \\ +\ldots+a_{0,t}(B_{t+t+1}-B_{t+t}), \tag{14}$$

$$\text{Н}_{t+1}-\text{Н}_t=a_{t-1,t}(B_{t+2}-B_{t+1})+a_{t-2,t}(B_{t+3}-B_{t+1})+ \\ +\ldots+a_{0,t}(B_{t+t+1}-B_{t+1}), \tag{15}$$

$$\text{Б}_{t+1}-\text{Б}_t=a_{1,t}(B_{t+t+1}-B_{t+t})+a_{2,t}(B_{t+t+1}+B_{t+t-1})+ \\ +\ldots+a_{t,t}(B_{t+t+1}-B_{t+1}). \tag{16}$$

Equations (13) and (14) are the difference of the adjacent lines and the columns t and t + 1 of the matrix, but (15) is the difference of the line t + 1 and the column t + 1, and (16) is the difference of the column t + 1 and the line t + t + 1 of the submatrices indicated above.

Considering (5)-(8) and performing the elementary transformations (13)-(16), we get first

$$a_{0,t}+a_{1,t}+\ldots+a_{t,t}=1, \tag{17}$$

$$a_{0,t}b^t+a_{1,t}b^{t-1}+\ldots+a_{t,t}=\frac{K_t(k-1)}{B_t(b-1)}, \tag{18}$$

$$(a_{0,t}b+a_{1,t}b^{t-1}+\ldots+a_{t-1,t})-(a_{0,t}+a_{1,t}+\ldots+a_{t-1,t})= \\ =\frac{\text{Н}_t(\text{н}-1)}{B_tb}, \tag{19}$$

$$(a_{1,t}+a_{2,t}+\ldots+a_{t,t})b^t-(a_{1,t}b^{t-1}+a_{2,t}b^{t-2}+\ldots a_{t,t})= \\ =\frac{\text{Б}_t(6-1)}{B_tb} \tag{20}$$

and after substituting (17) and (18) into (19) and (20) and making the transformations

$$B_t=K_t\frac{k-1}{b-1}-\text{Н}_t\frac{\text{н}-1}{b}, \tag{21}$$

$$\text{Б}_t=B_t\frac{b^{t+1}}{6-1}-K_t\frac{k-1}{6-1}\frac{b}{b-1}. \tag{22}$$

These ratios--we call them the equations of introduction (21) and of future investment in the facilities that have been started (22)--are of interest as macroeconomic models that permit investment processes to be analyzed and, what is especially

important, to be planned.* For an empirical evaluation of the value of t, we express (21) in terms of (5)-(7)

$$B_0 b^t = K_0 k^t \frac{k-1}{b-1} - H_0 \mu^t \frac{\mu-1}{b}. \qquad (23)$$

The statistics for 1958-1968 [12] give the following values for the variables of equation (23): B_0 = 7.8 billion rubles, b = 1.075; K_0 = 8.6 billion rubles, k = 1.084, H_0 = 7.4 billion rubles, and μ = 1.105.

After solving equation (23) we get t = 11.3 years, which also comprises the average length of the construction period for 1958-1968 (henceforth we shall adopt t = 11).

In order to compute the value of the elements of vector A, a second assumption--about the form of distribution of A--had to be introduced. It was assumed to be the same for the whole period as for a sample of 51 facilities introduced in 1966-1967 that the author studied. A correlation analysis of the sample's data indicated that the best statistical indicators have a parabolic form of connection of the type

$$a_{ji} = p\left[1 - \left(\frac{z-q}{t}\right)^2\right], \qquad (24)$$

where z = t - j; p and q are empirical coefficients, and for t, see (4). Substituting (24), t = 11, and the statistical data cited above for 1958-1968 into (17) and (18), we get, after solving the equations, p = -0.045 and q = 0.338.

A knowledge of the values for p and q makes it possible to determine, for the computed value of t, the coefficients of the "age" structure of the introduction a_{ji}, and also the fraction of capital investment of the year j in introduction in the year i and d_{ji} is the "age" structure of capital investment $\sum_i d_{ji} = 1$ for any j, in accordance with the formula (see column t of the matrix and (5))

$$d_{ji} = a_{ji} B_i / K_j. \qquad (25)$$

*Some works have proposed that t be evaluated on the basis of such functions as $t(j) = Б_j/K_j$, $t(i) = H_i/B_i$, and $t(i) = (H_i + Б_i)/B_i$ [9] (in the notation of that work). It follows from (21) and (22) that functions of this type give biased evaluations of the value of t. Let us note also that for a more detailed study of the ratios of introduction and capital investment, models of the theory of renewal can be used (see, for example, work [13]).

Values of a_{ji} for any i, $a_{ji} \approx a_j$, have been computed in accordance with (24) and of d_{ji} for any j, $d_{ji} \approx d_i$, in accordance with (25) (see table 2), and the duration of the construction period in accordance with modification (3)

$$T_i = \frac{\sum_j a_{ji} B_i (t-j+0{,}5)}{\sum_i a_{ji} B_i} - \sum_j a_{ji} (t-j+0{,}5), \quad 0<j<t. \tag{26}$$

Table 2

i, j	a_j	d_i	i, j	a_j	d_i
0	0,01	0,13	7	0,10	0,08
1	0,02	0,12	8	0,12	0,06
2	0,03	0,12	9	0,13	0,05
3	0,05	0,11	10	0,15	0,04
4	0,06	0,10	11	0,17	0,02
5	0,07	0,09			
6	0,09	0,08			

he value $\bar{T}_i = 4.0$ has been computed.* Consequently, of the capital introduced, more than half of it was for investment made 4 years prior to the introduction (but more than half of the investments are made for capital introduced no earlier than in 5 years). A comparison of the indicator obtained with the periods f r introducing such facilities as the KamAZ [Kama Motor-Vehicle Plant], the VAZ [Volga Motor-Vehicle Plant], the Nevinnomyssk Chemical Combine and some other facilities, and also with the average periods for industrial construction in the USA (1.2-1.3 years [14] and [15]) and Japan (1.9 years [3]), indicate a potential for a substantial reduction in construction periods.

For a further analysis of the investment cycle, it is useful to give an evaluation of the possible effect from reducing the duration of the construction period from 11 to, for example, 2 years (values which are, as is evident from the data cited above, achievable). The effect can be computed if a conception is obtained about the duration and distribution of the schedule of the investment cycle, where $j > t$ (in figure 2 the value T_{no} corresponds to this period).

*The curve obtained for the average construction periods differs from the evaluations of other authors for approximately the same period (1.5-8 [3, 6, 7 and 9]. This is explained by a departure in their definition and in computational procedure.

3. Determination of the Duration of Profit Making and the Distribution of Profit by Year of Operation of the Facility

There are many problems in evaluating the effect from introducing fixed production capital: choice of an indicator that reflects most precisely the dynamics of the effect and is suitable for use, from the facility level to the national economy level; the period within which the effect from introduction of the concrete year can and will be obtained; distribution of the effect in time; accounting for expenditures for upkeep of the operational qualities of the capital (which ordinarily lead to change of its initial cost); accounting for amortization in determining the dynamics of the residual cost of the capital; a comparison of the cost of the capital and the amount of the effect caused by change in the level of prices and forecast change of prices; and so on. These problems, which are associated with the effect of investment policy on national economic effectiveness, are studied most frequently by means of macromodels (see, for example [16-20]). For the purposes of this work, the period for computing the effect and its distribution in time are important. In order to compute the first of these, let us introduce a third assumption, which is not, like the two preceding ones, of a theoretical nature but which simplifies the conclusion--about the constancy of the annual effect $Э_{по}$ (which is taken as profit) over the whole period of functioning of the capital (see figure 2) and about the total duration of the investment cycle $T = \infty$.

The discounted effect $Э_T$ from the capital investment in fixed productive capital can be assessed over the entire investment cycle in accordance with data given above for determining it, in accordance with the known formula [9 and 21], the content of which is examined in Part 3:

$$Э_T=\sum_{j}^{T} Э_j(1+E)^{t-j}, \qquad (27)$$

where $Э_j$ are the annual expenditures and profit for capital investment at the facility or an aggregate of facilities for the year j, $j = 0, \ldots, t, \ldots$, where $Э_j = -K_j$ for $0 < j \leqslant t$ and $Э_j = Э_{по}$ for $j > t$; E is the coefficient of discounting (discounting is performed at the moment of the introduction of the capital t).

Let us examine the value of $Э_T$ where $j > t$. Where $Э_j$ is constant and $T = \infty$, the value of $Э_T$ can be computed according to the formula of the sum of a geometric progression with the denominator $(1 + E)^{-1}$

$$Э_T=Э_{по}\frac{(1+E)^{-1}}{1-(1+E)^{-1}}=\frac{Э_{по}}{E}. \qquad (28)$$

Let the value of $Э_T$ be determined sufficiently with the precision $\varepsilon Э_T$, which will make it possible to disregard part of the effect after the moment θ (see figure 2). The cumulative value of the effect from the moment t to θ (according to the formula for the sum of the geometric progression) is

$$Э_\theta = Э_\infty \frac{(1+E)^{-t} - (1+E)^{t-\theta}(1+E)^{-t}}{1-(1+E)^{-1}} = Э_\infty \left[\frac{1}{E} - \frac{(1+E)^{t-\theta}}{E} \right]. \qquad (29)$$

The difference between the precise and the approximate sums of the effect is

$$\varepsilon Э_t = Э_t - Э_\theta. \qquad (30)$$

After substituting (28) and (29) into (30), we have $\varepsilon = (1 + E)^{t-\theta}$. From computation of the value $\theta - t$ for various values of ε and E (table 3), it follows that the period for accounting for income from the capital introduced can be adopted with adequate precision in the magnitude of 14–30 years.

Table 3

E	ε	$\theta - t$	E	ε	$\theta - t$
0,08	0,1 0,15 0,2	30 25 22	0,12	0,1 0,15 0,2	20 17 14

Where $\theta - t = 14$ and the previously computed value of $t = 11$, we get $\theta = 25$. The value of θ is a computed part of the investment cycle T of capital-type facilities, on the basis of which it would be correct to establish a period that is covered during planning and design decisions which is often called the planning horizon.

Since the values of $\theta - t$ are close to the one computed by the author for other distributions of $Э_j$ (for $j > t$), we introduce, for the purpose of a more adequate conception of profit distribution, a fourth assumption: fixed production capital is recouped in 8 years, in accordance with [22–25], and the profit from it is proportional to the capacity utilization coefficient c_j, which we take in accordance with norms for the assimilation of capacity that have been averaged [26], equal to 0.4 in the first year, 0.8 in the second, and 1.0 in the third, after which it grows at 2 percent per year (in accordance with planning practice in many industries) until the 14th year of operation, after which it is reduced by 2 percent per year (the last two figures were based upon the author's research of the effectiveness of USSR Minmontazhspetsstroy [Ministry of Installation and Special Construction Work] enterprises, which usually beings to be reduced within 2–3 five-year plans if the enterprise is not rebuilt). Such a dynamic of profit can be explained by the fact that, given an average period of about 20 years for amortization of industrial facilities in the USSR, in the first period of their operation the effect grows as a result of the continuing assimilation of the capital, while in the second it is reduced because of growth of expenditures for repair and servicing. We compute the capacity utilization coefficient c_j and profit $Э_j$, which are expressed in fractions a_j of the cost of introduction B, $Э_j(B) = a_j$, for the period $t < j \leqslant \theta$, equal to the previously adopted planning horizon, after the deduction of 2 years (see table 4; let us recall that the purpose of Part 2 is a comparison of the effectiveness of the investment cycle where there are 2-year and 11-year construction periods).

Table 4

$j-t$	e_j	a_j	$j-t$,	e_j	a_j	$j-t$	e_j	a_j
1	0,40	0,05	9	1,12	0,15	17	1,16	0,15
2	0,80	0,11	10	1,14	0,15	18	1,14	0,15
3	1,00	0,13	11	1,16	0,15	19	1,12	0,15
4	1,02	0,14	12	1,18	0,16	20	1,10	0,15
5	1,04	0,14	13	1,20	0,16	21	1,08	0,14
6	1,06	0,14	14	1,22	0,16	22	1,06	0,14
7	1,08	0,14	15	1,20	0,16	23	1,04	0,14
8	1,10	0,15	16	1,18	0,16			

Now it is possible to evaluate the economic effect from reducing the construction time from 11 to 2 years (curves 1 and 2 in figure 2), where the planning horizon is 25 years. For this purpose, we substitute into (27), from tables 1 and 3, the values of the expenditures and the profit that are expressed in fractions of introduction, $Э_j(B) = a_j$, and we carry out discounting of the value a_j at the moment of introduction for each variant (that is, in the first case at $t' = 11$, in the second at $t'' = 2$--for explanation of the choice of the moment of adjustment, see Part 3). The values of $Э_T'$ and $Э_T''$, their difference, and the ratio of profit $Э_+$ to capital investment $Э_-$ for each variant have been computed for three values of E (table 5).

Table 5

E	t', t''	$Э'_T, Э''_T$	$Э''_T - Э'_T$	$Э_+/Э_-$
0	$t'=11$ $t''=2$	+0,93 +2,51	+1,58	1,93 3,51
0,08	$t'=11$ $t''=2$	−0,26 +0,37	+0,63	0,80 1,36
0,12	$t'=11$ $t''=2$	−0,72 −0,04	+0,68	0,54 0,96

It stands to reason that evaluations of the effect of a reduction in construction time are tentative, since substantiation of the potential thereof requires analysis of a large complex of social and economic factors. For this reason, for example, the additional effect from reducing the costs of construction by reducing its duration, which in this case could be, according to the author's evaluation, 13 percent of the cost of introduction, has not been computed. Nevertheless, the results of carrying out the computations enables an important conclusion to be illustrated: a reduction in the length of the construction period of investment in an industry can yield an effect that is comparable with the cost of the fixed capital introduced. Obtaining it would lead to a radical change in the national economy's effectiveness indicators. However, providing for optimal length of the investment cycle is contingent upon the solution of a number of complicated problems.

3. Consideration of the Characteristics of the Investment Cycle in Economic Computations Practice

Recommendations for reducing construction time come down most often to a reduction of the number of facilities being erected simultaneously and to paying the construction activity for completed facilities or major portions thereof. Research performed by the author has shown that these conditions, which are far from unique, should be more the consequence of optimal control of investment processes than its purpose. A change in construction time requires primarily a consideration of the actual complexity of construction work as a system, and this is possible only with the simultaneous coordinated improvement of the management, organizational structure, technology and financing procedure of the construction activity itself and of its mutual relations with other branches of the economy. One of the aspects of this complexity is the objective requirement, provoked by the NTR [scientific and technical revolution], for a reduction in the total duration of the investment cycle--both of its construction portion and its operations portion--because of acceleration in the obsolescence of industrial equipment and processes. One can therefore say that the degree of utilization of the NTR's potential and, therefore, of growth in national economic effectiveness, are functions of skill in managing the investment cycle.

Let us dwell upon just one question of optimal control of the length of the investment cycle--the use of the conclusions that ensue from analysis of the cycle in economic computations (some of the other questions are examined in [10 and 27-29]).

1. Consideration of the Precision of Evaluating the Economic Effectiveness of Investment. In all existing documents for evaluating the economic effectiveness of decisions that have been adopted (see [22-25]), the basis for choosing one of the decision variants being compared is the greater (or lesser) value of the criterion of effectiveness. An analysis of investment-cycle dynamics leads to the concept that, since the consequences of economic decisions cannot be evaluated precisely, decision options can be compared only by taking the precision of their technical and economic indicators into account.

Suggestions for determining the precision of computations are offered repeatedly for economic systems, just as is done for technical systems.*

Obviously, it is desirable that documents [22-25] include an indication of the diversity of the options with respect to economics if the difference in their effectiveness is less than the established (or estimated) precision of the effectiveness evaluation.

2. Choice of the Moment for Attributing Expenditures and Effects That Vary with Time. There are various points of view on the choice of the time for attribution. Work [24] points to the necessity to reduce to "one moment of time (the start of the computations year...expenditures for the creation and introduction of new and basic equipment and the results of their application." [Work [32] pointed out that

*See, for example, work [30]. In work [31], differences of at least 5 percent in expenditures and at least 7 percent in time spent erecting structure are introduced as prerequisites for choosing one of several options.

the choice of the more effective option does not depend upon the moment of attribution. There are enough such recommendations for comparing variants, regardless of the concrete finance-planning situation. However, if the rubles that are at work in the economic computations are not the same rubles that can be recorded in balance-sheet reports or in the bank settlements of enterprises and organization, such "double bookkeeping" can lead not only to the lack of a check on the economic theory of economic practices, but also to loss of actual rubles obtained on paper but not obtained in actuality.

If the question of whether discounted expenditures and profit correspond to the actual economic indicators is asked, then the search for an answer can increase precision of the requirements for the moment of attribution. The thought of the procedure for discounting, as is known, consists in calculating an extra charge for capital investment and deductions from profit. Extra charges for capital investment (for example, in the form of payment for credit when construction is financed through bank sources) should compensate for the withdrawal of funds from circulation. Perhaps it is even desirable to fix terminologically the difference between net and gross expenditures for construction, counting only the first as capital investment and outlays plus the discount (or payment for credit) as investment.

Deductions from profit (in the form of payment for capital, let's say), should serve the purposes of unearned redistribution of effect among new and old enterprises (the discounted profit in this case is the analog of net profit as opposed to balance-sheet profit, the analog of undiscounted profit).

Under such an interpretation, discounting is a prerequisite to providing for expanded reproduction, that is, for the recoupment of discounted expenditures through discounted profit, for the period that corresponds to the reproduction cycle, and the natural moment for attribution is the start of the functioning of the enterprise introduced (where losses are planned for the period of assimilation of the capacity--it is the start of profitable operation). Then the discounted expenditures themselves and profit become not simply provisional indicators of the effectiveness of the options being compared but indicators that are computed during the design of the facilities and are included in the five-year and annual plans (primarily financial plans). For each construction variant or for each enterprise planned for construction, the moments of attribution for a given planning horizon will, in general, be different.

Thus the use of discounted indicators for expenditures and profit in planning and design practice would enable solution of the question about the designation of the amount of the discount as an indicator that regulates the flow of investment and questions about bank monitoring of investment realization, construction dates and the use of discount deductions.

The lack of a realistic mechanism for getting the discount is equivalent to the lack of an effective mechanism for providing for expanded reproduction, within the hypothesis of which indicators of the economic effectiveness of investment are constructed. The conversion of construction to credit grants (with an increase in the payment for credit when standard construction deadlines are not met) that is now being implemented is, along with the payment for fixed productive capital, which has already been introduced, an important step in the creation of such a mechanism.

3. Computation of the Planning Horizon. The introduction of the planning horizon into planning and design computations when evaluating the effectiveness of specific facilities leads at first glance to an undercounting of a certain portion of the effect in cases where the service life extends beyond the planning horizon. However, this deficiency is only an apparent one if it is considered that those changes that lead to a considerable difference between actual and designed indicators during the first years of an enterprise's operation usually are not considered in design and planning practice. Such changes are linked with the reconstruction of enterprises (which have a periodicity of 2 to 10 years in some industries and are marked by a trend toward increasing frequency), the reequipment thereof, and an increasing pace in the updating of output, leading to still more frequent changes in the enterprise's profile and in the products mix of its output.

It is not the period for recoupment of outlays (which does not correspond to actual recoupment and is in practice neither planned nor monitored) that dictates the introduction of economic computations of demand into practice, but the effect on the concrete planning horizon will help to direct the designers' and planners' attention not only to the facility's design indicators on the tentative date of assimilation of capacity but also to the entire dynamics of the facility's development and the expenditures and effects during the period being planned, and it will enable the incorporation of solutions that will facilitate reconstruction and reequipping with machinery.

The planning horizon can be set at 20 years (the five-year period that is being planned plus 15 years after completion). It is desirable to establish a procedure under which, when the effectiveness of the objects of investment is uneven by year of operation, the designs will specify their indicators for all years of the planning horizon or the service life (if it is less than the planning horizon), while facility-by-facility plans will show it--depending upon the planning methods--either for all years of the planning horizon or for all years of the first five-year plan and for the last years of the three following five-year plans--with a view to accounting for yearly constraints on implementation of the investment and the contribution of the facility to the industry's profits by specific year.

Since capital investment and other technical and economic indicators of industries and their organizations and enterprises are at present planned in isolation and the horizon of the plans does not exceed the period being planned, it is obvious that a consideration of this horizon is directly linked with the introduction at all levels of control of a much-needed form of planning--specific-program planning.

4. The Time Factor and the Ties of the Object of Investment. An accounting of the time factor provides not only for comparability of expenditures that vary with time but also (which is just as important and much more difficult at a time when the organizational structure of the national economy and its branches is constantly becoming more complex) for the integrated covering of ties (and consequently of the expenditures and effects) of a concrete object of investment in the system of the national economy, the branch thereof, and the region. Very often attempts are made to reflect such ties in the criteria for evaluating the effectiveness of objects of investment, which occur also in certain formulas in documents [22-25]. It is important to demarcate the methods as well as the spheres for accounting for effectiveness of the objects of investment.

The effectiveness criteria for an object of investment should establish a kind of consolidated evaluation of the expenditures and the effect on the basis of which planning, design and production decisions are adopted. The introduction into the criteria of a fixed set of stages of production (for example, the manufacture and operation of machines) is not entirely correct, for two reasons. First, such sets, as a rule, are not complete. Second, coverage of the indicators for various stages of production and operation of an object of investment makes sense only where they are concurred in prior to the adoption of decisions by the appropriate organizations, whereas at present such an accounting not only has not been regulated in any way, but often does not even come to the attention of the organizations which, it is presumed, receive the effect from investment in, for example, new machinery.

As for the ties of the object of investment, they should be reflected in plan models and documents. Thus, the Standard Practices Instructions of USSR Minmontazhspetsstroy [33] includes standard sets of stages of production (the manufacture of output, production of the means for its manufacture, transportation, supply, installation and operations) and steps for executing all programs, including investment programs (the fulfillment of NIOKR [scientific research and experimental-design work], the conduct of construction and installing work and of startup and setting-up operations, the development of standards documentation, preparations for production, personnel training, industrial production, and the acquisition and assimilation of the object of investment). Under this approach, all the ties of the object of investment find reflection in the plan's program document, and all the indicators that characterize expenditures and effect are coordinated by the organizations that enable them to be received.

Let us also note that the necessity for taking the dynamics of investment effectiveness into account is occasioned to a great extent by the structure of the national economy. The constant increase in its complexity, caused by an intensification of specialization and by an organizational breakdown into ever newer and newer types of activity, leads to the decisions that relate to one object of investment being influenced, in most cases, by various organizations that are independent and not subordinate to one another. Ties that are disrupted because of the new organizational structures can be compensated for either by some system of centralized adoption of investment decisions that is adequate for the national economy's intricacies, or by local mechanisms for their economic regulation, or a combination of the one and the other.

5. Prerequisites for Choosing and Using Effectiveness Criteria. Of all these prerequisites, three are basic.

The first is /interdependence with planning methods [in italics]./ The comparison of various options and choice of the best of them proposed by works [22-25] have been constructed on the basis of the unclear suggestion that only the economic advantages of a variant are the basis for a solution and that there is an adequacy of everything that is necessary for the realization of any option (that is, realization is unrestricted). However, these prerequisites--especially the second--are fulfilled extremely rarely. In actuality, during planning, not only are variants of a concrete object of investment compared with others, but also many facilities that are connected by a general purpose and require the very same resources for realization emerge as variants. As indicated in [27], during optimization of branch-of-industry solutions for an individual variant, not so much its effectiveness in relation to hundreds of other as its entry into the optimal plan is the

determining factor. An analysis of effectivness (comparative and absolute) in this case makes sense for the plan as a whole, in order to establish an optimum level of restraints [27].

The use of optimal planning methods changes the requirements for the effectiveness indicators, since in this case profit, net output and national income, plus the cost of services or other indicators, emerge as efficiency functions, and capital investment emerges as a constraint (along with other types of them). In many cases, the purpose of investment for a concrete object is to obtain an effect not for this object (or not just for it), but primarily for the system (or the region, branch or national economy) as a whole.

In choosing effectiveness criteria the existence of a system of interdependent long-term, specific-program, five-year and annual planning is important. Specific program and annual planning are of special importance. The first type enables (see part 4) a group of expenditures and effects for a specific object of investment to be determined accurately--from design to production. The existence of a modern system for annual planning, as indicated by experience in the development of such a system for controlling the production and shipments of metal constructional structure that embraces all stages (design, planning and production) and levels of control [28 and 29] (from plants and trusts to USSR Gosplan), is mandatory to the realization of annual tasks of programs for individual objects of investment.

The second prerequisite is /the existence of a financing mechanism for controlling the effectiveness of investment processes [in italics]./ It is examined in part 2. The use of discounted expenditures and effects is desirable only with the existence of the appropriate financing mechanism for discounting.

The third prerequisite is /simplicity and clarity [in italics]./ Simplicity in calculating attributed expenditures and recoupment periods promotes wide use of these criteria. The simpler and clearer the recommended criteria are to the designers and planners and the more directly they become linked with those actual indicators by which the work of enterprises and organizations is evaluated and stimulated, the more probable it is that more effective decisions will be chosen during design and planning.

6. Effectiveness Criteria and Their Use. Documents [22-25] call for several criteria for evaluating effectiveness as a function of organizational levels for determining it (attributed expenditures in several modifications and the ratios of profit and net output or national income to capital investment) and of the goals of the calculations (absolute and comparative effectiveness). In practical calculations it is desirable to use (in accordance with the considerations set forth above for providing for the actual recoupment of investment) the basic statements of documents [22-25] as follows:

a. Evaluate one-time exenditures (investment) by the discounting method of the capital investment in introducing them into programs, designs and plans (along with the nondiscounted value thereof); establishment of values of the discounting coefficient, its tie with payment for credit, payment for capital and other indications of investment dynamics and unearned payments should be coordinated with the actual bank-financing and planning mechanism for meeting the requirements of expanded reproduction;

б) Evaluate the effect on levels up to the branch-of-industry level, inclusive, for a planning horizon of 20-25 years, after establishing the appropriate indicators for the designs and programs associated with the investments;

в) Discount expenditures and profit at the moment of introduction of the objects of investment or the planned start of their loss-free operation;

г) Compare and choose investment-decision variants during long-term, specific-program and five-year planning, and also during the design of facilities for a planning horizon of 20-25 years, using the methods of optimal planning in accordance with the criterion

$$Э_+ \to \max \tag{31}$$

with $Э_- \leq Э_-^{п}$, and $K \leq K^{п}$, where $Э_+$ is the discounted profit, $Э_-$ is the discounted capital investment, $Э_-^{п}$ is the planned amount of financing of the investment, K is undiscounted capital investment, and $K^{п}$ is the planned amount of capital investment ($Э_-$, $Э_-^{п}$, K and $K^{п}$ are related to the very same planning periods and facilities or programs); when this is impossible, compute the restrictions on execution of the investment in accordance with the maximum of the criterion $Э_+/Э_-$;

д) Introduce into works [22-25] a requirement for the consideration (or computation) of precision in evaluating the effectiveness of the options of the solutions being compared, while they are being chosen;

е) Add to work [26] and to construction norms a requirement that expenditures and profit for the aggregate of all the unified stages of production and steps of development be computed in programs and designs during evaluation of the investment-decision variants;

ж) Include in work [26] the requirement for a check for the higher levels (for example, branches, ministries and agencies) of the design and planning decisions adopted for the lower levels (for example, individual enterprises and organizations) in accordance with the criterion

$$\frac{Э_+}{Э_-} \geq 1 \tag{32}$$

(the notation is the same as for (31).

These recommendations correspond to the requirements for full recoupment of all elements that take part in investment processes, for their orientation to the final results of construction, and for the introduction in the required procedure of payment for investment credit and capital that is called for by the CPSU Central Committee and USSR Council of Ministers decree of 12 July 1979, "On Improvement of Planning and Strengthening of the Influence of the Economic Mechanism on Increasing Production Efficiency and Work Quality."

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11409
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METALWORKING EQUIPMENT

INDUSTRIAL ROBOTS EXHIBITED IN MOSCOW

Moscow PRAVDA in Russian 25 Feb 81 p 8

/Article by E. Svetlanova: "To Plants of the Future"/

/Text/ At the VDNKH /Exhibition of the Economic Achievements of the USSR/ in Moscow an exhibition of automatic manipulators has opened to coincide with the 26th Party Congress. In the report to the 26th Party Congress are these words: "The creation and adoption of miniature electronic computers and industrial robots are opening truly revolutionary opportunities. They must be used as extensively as possible."

From one exhibit to another, from the first generation of robots with rigid programming to sensitive robots capable of handling unexpected barriers and independently solving problems in an external environment we somehow are following a path to the plants of the twenty-first century.

In forge and press operations during the punching it is necessary to work with red-hot billets. The forging manipulators being shown at the exhibition demonstrate their ability to pick up such a billet with their durable "hands", to easily turn it and load it into the heating oven and then skilfully remove it.

The visitors spend a long time following each motion of the robot-assembler on the production line that turns out transformers. The robot came to the exhibition directly from the conveyor of a machine building plant. One of the manipulators has extended its "hand", taken a small spool and connected it accurately to the lower pair of cores; another robot has done the same thing with the upper pair. Along the way the robot has also checked the dimensions and electrical properties of the manufactured article. It has glued the parts and put them into position to be dried. The manipulators with their irreproachable accuracy dictate to the other components of the sector, with which they work, an equally high degree of labor quality and its organization.

The exhibition guests gaze intently upon the imperceptibly rapid motions of the manipulators, which comprise the multi-position robot that assembles the delicate wrist watches. It was created by specialists from the Petrodvorets watch plant who have won a USSR state prize.

In the hall of future work which is the central part of the exposition great interest is given to the integrated adaptive robot. One can communicate with the robot using common speech through a microphone. It is true that the "interlocutor" understands only 24 words, but in combination these words can be used to issue as many as 200 commands.

The robot turned its long "neck", moved toward the conveyor, found a socket for an electric light bulb and carried it to a nearby table. Another manipulator seized a red lightbulb with its rubber "fingers", put it into the socket, twisted it and the lightbulb was lit.

There is, of course, no production need for this operation; it only demonstrates the possibilities of a robot. It has television sight; its "hands" are equipped with tactile sense devices; and it is controlled by a mini-computer. The automatic equipment can work with objects of any form, including fragile items.

Professor and Doctor of Technical Sciences Ye. I. Yurevich, the manager of program of work on industrial robots of the USSR State Committee for Science and Technology, tells us about the future of Soviet robot building.

"I will name three main trends," he says. "The first is the creation of industrial robots with adaptive control and elements of artificial intelligence. The second trend is the creation of such automatic manipulators, which will ensure a basis for the comprehensive automation of various sectors of industry. This includes sectors of industry which have not yet received robots. For example agriculture, transportation, construction and the service sector. Finally, the third trend is the transfer to the creation of robots for the most effective module principle, where from individual standard parts one can construct different variations of automatic equipment and entire sets of robots. This will help the technical re-equipping of production. Industry must switch to the manufacture of sets of machine tools using robots that are organically connected to them. The primary task is to make the labor of man easier.

8927
CSO: 1821/63

METALWORKING EQUIPMENT

MANY USES OF INDUSTRIAL ROBOTS DISCUSSED

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 5 Mar 81 p 4

/Article by D. Pipko, correspondent: "Professions of Robots"/

/Text/ "The creation and adoption of industrial robots are opening up truly revolutionary opportunities. They must be used as extensively as possible." (From the report to the 26th Party Congress)

The intersectoral exhibit of automatic manipulators received its first visitors on the eve of the 26th Party Congress. The exhibit clearly demonstrates ways to solve the important task "to substantially increase the production of systems of machinery and equipment, especially automatic manipulators with programmed control which make it possible to do away with manual labor in unskilled and monotonous jobs and in conditions that are both difficult and harmful to man.

The exhibit, which will now be open at the Exhibition of the Economic Achievements of the USSR in Moscow, was sponsored by representatives of 16 ministries and agencies, who displayed nearly 60 exhibits. Today we will discuss some of them.

This is How They Learn

"Shake hands," said Teleshov to his ward.

With trepidation I extended by hand toward the rigid palm. But its black fingers were soft but strong as they grasped my hand.

"Do not be afraid," the scientist hastened to reassure me. "We are working with fragile light bulbs. And none have been broken. Let us show them, Chik?"

The robot immediately released my hand as its open hand shot upward and froze in anticipation. But Nikolay Sergeyevich started the revolving round table on which, from a special attachment, the glass bulb of the lamp protruded vertically. The bulb proscribed circle after circle in front of the robot, but the robot did not move.

"It does not know how to pick up moving objects. It might miss," explained Teleshov. "All the same, you see, the table surface is still wobbling. Therefore, Chik needs an assistant. Chak, get ready!"

A second jointed "hand" which we had ignored initially, with its gears rumbling, came out of the table. In contrast to the first robot the "hand" of the second robot ended with an iron claw, which resembled enormous flat-nosed pliers. Swaying, the claw hung over the table like the head of snake preparing to strike. It seemed that the studded lit points were greedily following the bulb as it moved on the round table.

"Attention. Begin!"

These words were scarcely spoken when the head of the "snake" darted forward. In an instant the "flat-nosed pliers" had grasped the base of the bulb lifted it and froze above the table. Chik's open hand was already on its way to meet it. The black fingers carefully grasped the glass bulb and placed the base of the bulb in the electrical socket and quickly turned it. When the light bulb came on, the robot just as carefully turned it and put it into one of the receptacles of the cassette that was standing on its side.

"That is all," pronounced Teleshov as he put down the microphone. "The robots have performed their job, having removed the light bulb from a moving carrier, checked to see if it works and placed it in its package."

"What happens if the light bulb does not work?"

"Then Chik would put it into the cassette for defective articles. Do you see the photocell?" The scientists pointed to an instrument next to the socket. "The photocell reacts to sparks and tells the robot how to deal with each light bulb. By the way, we have taken the light bulbs just for the sake of simplicity. Our bench was created for completely different purposes.

Officially, Chik and Chak are component parts of one experimental robot, the LPI-2. They can be called whatever you like. It is only important that a device that can accept voice commands know their names. Apart from this device, the LPI-2 also has a "brain" - a computer, a lever on the control panel for manual operation, and supervisory vision - the eye of a telecamera which turns above the table. At the exhibition the table lost ground to the conveyor belt, but this did not change anything: the scientists of the Special Design Bureau of Technical Cybernetics (OKB TK) of the Leningrad Polytechnical Institute who created the bench did not skimp on the equipping. They did not skimp in tuning the complicated relationships of the industrial robots with the surrounding world and actual production. And most important with each other.

"Modern robots like numerically controlled machine tools are controlled by a rigid program," said the manager of the OKB, Doctor of Technical

Sciences, Professor Ye. Yurevich. "This leads to many problems with their adoption. The majority of the robots, for example, can pick up parts only from a specific position indicated in the program. What happens if the part is not in this position for some reason? Or, let us say, the conveyor has moved it a bit further? In the best case, having missed, the robot stops. In the worse case, the robot closes its claw and delivers a handful of air to the machine tool. Because of this the conveyors that are served by the robots have to be shut down in working positions. And on the immoveable racks the parts have to be put back into order."

"But our LPI-2 picks up moving objects - those light bulbs that are turning with the table."

"For this reason it is a second generation robot, with technical devices which replace the organs of sense. How many ultrasound transducers do you think are built into its claw? There are 12! Some of them function as locators and help the claw to slide above the table precisely at the level of the base of the light bulb; another group of transducers guide the robot's "hand" to its target; a third group determines the distance to the light bulb and helps to grasp at the correct time. But we dare not entrust even this "sensitive" claw with picking up a bulb by its glass shell."

Why? If were talking about a simple robot, the doubts of the scientists could be understood. The iron fingers of the claw cannot be permitted to open as much as a millimeter without the bulb slippling out. Compress the robot's fingers a tiny bit more and the buld would be nothing but broken glass. But the LPI-2 is a second generation robot. Couldn't they, for example, equip the claw with tacticle transducers which react to the slightest touch of the glass?

"In principle, this is possible," replies Yevgeniy Ivanovich. "But is this necessary" We have divided responsibilities between the two "hands" for good reason. The "sensitive" claw with the ultrasound transducers performs the most complicated part of the operation - it catches the bulb by its base on the revolving table and delivers it to a predetermined position in space. The hand of a simple robot working in accordance with a rigid program can easily intercept the buld in this position."

"But where is the guarantee that this hand will not shatter the shell of the bulb when working at such great speeds?"

"In its design. You saw for yourself that it is made of synthetic rubber, like the glove of an electrician. Only on the exterior side of the fingers there are corrugated ridges. If you fill it with compressed air , this "bellows" is inflated. And it forces the fingers to bend.

"It turns out that at the present stage of inventiveness robots can get by without complicated organs of 'sense'."

"This is what we wanted to show by dividing responsibilities between the two 'hands'. 'Sensitive' robots are complicated and expensive devices. For this reason even plans for the future do not emphasize them alone. It is much more advantageous to have brigades of robots where one 'sensitive' robot is served by several simple robots. But first we have to teach the robots to work together in a 'collective'. This is why we created the LPI-2."

> One can only be amazed at how quickly robots and manipulators are assimilating new professions. If we trace the origin of our machinery, instruments and devices, we find that the majority of their basic operations are now being performed by robots.

The Robot as a Foundry Worker

Where, for example, does any new machine begin? With the castings for its future parts. The participation of robots in the manufacture of machines begins with foundry production.

An automatic line for pressure casting, the A711A08 - this is the name of an equipment set, which was created by specialists from the Special Design Bureau of the Tiraspol' Casting Machine Plant in cooperation with scientists from the Odessa Scientific Research Institute of Special Casting Methods. Three manipulators simultaneously serve its casting machine. The first is a manipulator-caster, whose functions consist of using a bucket to scoop up a portion of metal from the oven, conveying it and pouring a precise amount into the opening of the mold. Due to the inventiveness of the designers, this operation is performed by a comparatively simple manipulator much as it would be done by a skilled worker.

For example, let us say that two wires lead from under the "hand" of the pourer. When the "hand" is lowered into the vat, as soon as the two wires touch the surface of the metal the electrical circuit is closed. When the manipulator receives the signal about the level of the melt, it does not lower the bucket any deeper than necessary. In addition, there is an opening in the bucket through which the excess metal is poured. This makes the proportion precise and accounts for the high quality of the castings.

The latter point depends upon the second manipulator, which with the use of atomizers cleans the mold and applies a thin layer of lubricant. But the third manipulator has the biggest job: it extracts the castings from the mold, lowers it into a vat with a cooling liquid, feeds it into a trimming punch and, finally, throws it into a package.

Having freed the worker from these boring operations, the manipulators require him to monitor the progress of the process. The worker can operate two sets at the same time. Productivity has increased by 1.8 to 2-fold and the smoothness of the work and the quality of the castings are improved.

The Robot as a Stamp Operator

Production engineers have formulated the task: to convert a sheet billet into a part it is necessary to remove the billet from the feeder bin, feed it into the punch of the first punching machine, remove it, turn it, "pass" it through the second punch and deliver it to the receptacle for the finished product. There is one condition: the high-speed punching machines must not stand idle. One asks how many manipulators are needed to keep the punching machines busy?

"One," replied the specialists of the Experimental Scientific-Research Institute of Forge and Press Machine Building. And they created an automatic manipulator...with three "hands". Their pneumatic cylinders are at right angles to each other and are connected by a sort of cross brace, which turns around a vertical axis. All equipment is installed strictly "under the bores" around these cylinders.

At one particular moment the robot is stopped with the closed rods of its "hands" - their magnetic "suction devices" are now empty. But the programming device issues a command and the "hands" simultaneously shoot forward, seize the "extraction" and return to the initial position: the first "hand" holds a billet from the fdeder bin, the second a semifinished product from the first punching machine, and the third holds a finished part from below the second. The "cross brace" makes a 90 degree turn and the "hands" again shoot forward; the first two "hands" load the punching machines while the third delivers the finished product to a receptacle. Now the cross brace has only to return to the initial position and the manipulator will be ready to repeat the cycle.

The use of a manipulator in this kind of robotized production sector increases productivity by 1.3 to 1.8-fold and excludes the danger of injury and makes it possible to organize the servicing of many machine tools at one time.

By the way, sometimes it is necessary to use two manipulators with one punching machine. This is how the problem was solved, for example, in an automated equipment set for seam stamping, which was created at the Taganrog PKTI [Designing and Technological Institute] of Forging Robots. Having divided up the feeding of hot billets into the punch and the removing of the finished forged pieces, they jointly perform the remaining operations upon the commands of the cyclic system of programmed control. The yearly economic savings from the adoption of the equipment set is more than 100,000 rubles.

The Robot as a Welder

Industrial robots assimilated the job of welder early in their career. But basically in the building of automobiles where they have to work with sheet metal. The designers of the All-Union Designing Institute of Welding Production gave themselves the task of expanding the use of mechanical assistants. And they came up with an automatic manipulator for the electric arc welding of thick-walled parts.

One of the main requirements was that the "hand" carrying the welding torch must be able to make complicated trajectories in space. But the designers executed it with minimal "losses": they gave the manipulator the ability to operate in a mixed system of coordinates and the torch itself the ability to move in five different ways. It can simultaneously move forward and backward, left and right, up and down and turn around both a vertical and a horizontal axis. But even at the greatest speeds the torch maintains high precision of movements: errors do not exceed .6 millimeters.

The ability to weld various parts is acquired by this manipulator during the training process: upon commands from the control panel the operator forces it to perform the necessary motions. Simultaneously the operator supplies both data on the geometry of the manufactured article and the processing program into the control system. The manipulator performs this program while operating in an automatic mode.

The Robot as a Machine Operator

The beam of the monorail, which extends above three powerful lathes, even externally emphasizes their organic unity. Constructed in a line they form an automated production sector for the processing of the ASVR-02 shafts, which was created by the designers of ENIMS /Order of Labor Red Banner Experimental Scientific-Research Institute of Metal Cutting Machine Tools/. In essence this is an automated production line. But a special production line that is easily adjusted to handle new manufactured articles. In order to use it to perform a series of needed operations, the parts can be moved from one lathe to another in any order. The UM-160 robot, which slides along the monorail, makes this possible.

The range of its responsibilities is broad: it checks to see if there is a billet in the storage unit; it measures their length and diameter; it sorts the billets by size; feeds and removes the shafts from the lathes; and delivers them to the place where they leave the sector. And all of this is done to parts which may weigh as much 160 kilograms and be as long as two meters. The sector's lathes perform work on the parts within the limits of second and third level precision both on cylindrical and shaped surfaces; they cut bevels, thread and make grooves. And the tailings are carried away by transporters. And the safety of servicing the lathes is guaranteed by a special system of light protection.

The overall program of motions of a robot is provided by training. And the servicing programs of each lathe is stored in the memory of the control device. The required program "turns on" the robot, which arrives on command from the lathe. If two lathes simultaneously command the robot to come forward, the robot responds to the one that has the longest processing cycle. This "strategy" has justified itself: the use of the ASVR-02 sectors promises an annual economic savings on the order of 30 to 80,000 rubles.

In comparison with this sector the "lathe-manipulator" set created by the Novosibirsk Branch Orgstankinprom appears very modest. A simplified design automatic manipulator, the SN-33, is fastened by its monorail directly to the forward head of the lathe. But its "hands" make it possible to free two men and to assign to one worker the servicing of five lathes and also to raise productivity by 30 percent.

The Robot as an Assembler

What qualities are needed by a worker who stands at the assembly conveyor? First of all he must have increased attention and exceptional accuracy of motions. On an automatic production line for the assembly of the LAST-1 transformers the first of these qualities is replaced by numerous guages. But the "hands" of the two pneumatic manipulators that service the line come to the working positions with an accuracy of .15 millimeters.

This entire equipment set can be called a robot-assembler. While subordinate to the program, supplied by a printed circuit, its conveyor feeds the spools of the transformers into the working position. Here the first manipulator, with no loss of time, puts the brackets of the lower pair of cores onto the spool. Meanwhile the second manipulator having taken the brackets for the upper pair from the feeder first lowers their ends on the cushion with glue. Only then does it put them on the spool.

Actually this completes the assembly. But the conveyor carries the transformer through the drying chamber where the glue completely dries. As the manufactured article leaves the conveyor it is met by monitoring guages. Having attached themselves to the transformer, the monitoring guages measure the transformers' electrical characteristics. If the latter are within the norms, the manipulator permits the article to move on; if not the manipulator removes the defective transformer from the conveyor cell. It takes only 12 seconds for all of these operations; the productivity of the LAST-1 production line is 300 transformers per hour.

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METALWORKING EQUIPMENT

ADVANTAGES OF INDUSTRIAL ROBOTS DISCUSSED

Moscow MOSKOVSKAYA PRAVDA in Russian 17 Feb 81 p 2

/Article: "A Robot Can Do It"/

/Text/ Specialists from ENIMS /Experimental Scientific-Research Institute of Metal Cutting Machine Tools/ adopted the Soviet Union's first production sector to be serviced by an industrial robot at the electrical machine building plant "Dinamo" imeni Kirov.

Initially a man who happened to visit the production sector might think that it was inactive. No machine tool operators can be seen; and no loud noises can be heard as the heavy billets, which are to be converted into shafts for the electrical units, are fed into the "mouth" of the machine tools. But the main "actor" after an instant demonstrates its many abilities. The "hand" of the manipulator, as if it is a bit of fluff, seizes from the carriage a nearly 200-kilogram metallic cylinder. In counted seconds the robot delivers via the monorail the billet to one of the three machine tools that it services and precisely according to the program it takes the already finished shaft fror another machine tool and supplies it with a billet and then takes the article from a third.

It is difficult to imagine a man who could work at this pace with such a large load. But the UM-150 robot, which was born in the laboratories of ENIMS and in the shops of the experimental plant Stankokonstruktsiya and which has received a permanent place at the Dinamo plant, surpasses any skilled workman in abilities at the machine tool. But the robot is is of little value without the very sophisticated electronic equipment set that controls the entire production sector and carefully monitors the technology. Such a combination of modern mechanisms and an electronic "brain", in the opinion of specialists, will determine the nature of shops and enterprises of the future.

And it is coming into being today. If the production sector, which is served by a robot created by ENIMS for the Dinamo Plant, was one of the main accomplishments of the Tenth Five-Year Plan, then the Eleventh Five-Year Plan will be a time for the birth of an entire series of equipment sets based on automatic robots and series produced machine

tools. And these will not be experimental models - such production sectors are to be the industrial product of Soviet machine building.

Automatic manipulators, significantly improved mechanisms, which are replacing man in the most labor-intensive and harmful tasks and in monotonous operations, are changing from semi-fantastic ideas to reality. The past five-year plan was a very important stage toward this end, when unique designs of the Moscow designers left the laboratories and went into the plant shops.

The first year of the new five-year plan is to take the next step. It will be taken by the scientists and designers of ENIMS in cooperation with the innovators of the machine tool building plant Krasnyy proletariy imeni Yefremov. In one of the shops of this plant an automated production sector will begin operating which is made up of machine tools with numerically controlled programming, which are serviced by an industrial robot. Its adoption will double the labor productivity. The first stage of this work is being completed ahead of schedule in honor of the 26th Party Congress.

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METALWORKING EQUIPMENT

MORE ON EXHIBITION OF INDUSTRIAL ROBOTS IN MOSCOW

Moscow EKONOMICHESKAYA GAZETA in Russian No 11, 1981 p 24

/Article by M. Makhlin: "Automatic Manipulators-81"/

/Text/ At the VDNKh of the USSR an intersectoral exhibition of the "best models of automatic manipulators" has opened. The exhibition was organized in accordance with the CPSU Central Committee decree on measures to increase the production and to extensively use automatic manipulators. Seventy nine industrial robots are on display in the six halls devoted to the "machine building" pavilion.

In the report of the CPSU Central Committee to the 26th Party Congress Leonid Il'ich Brezhnev said: "The creation and assimilation of miniature computers and industrial robots are opening up truly revolutionary opportunities. They must be put to use as extensively as possible." These words are becoming the slogan for the exhibition.

In the Tenth Five-Year Plan the machine building enterprises received 7,000 automatic manipulators. This has made it possible to free from heavy manual labor 20,000 workers. In the Eleventh Five-Year Plan 40 to 45,000 robots will be put to work in the machine building sector; this will provide the opportunity to free from 100,000 to 120,000 workers for other work.

Each of the displayed manipulators is capable of replacing two to three workers. This is especially valuable in the heaviest and most monotonous jobs. In the "hot" shop or in the so-called harmful production facility industrial robots never tire. The deviations in the precision of their motions are measured in the millimeters.

In the forge and press and punching production work there are now employed 35 percent of the entire park of robot-machine builders; in mechanical work one in five; and in foundry work one tenth; eight percent are used in electroplating; five percent in assembly operations, heat treating, lifting and transport and warehousing operations; and less in welding, painting and other production operations. As can be seen in the data cited on one of the information stands, automatic manipulators are specialized far from equally. The exhibition is aimed at opening new opportunities of the miracle equipment and to motivate specialists to put it into operation.

The use of automatic manipulators in electroplating, for example, increases labor productivity by 2.5-fold and increases the use of equipment capacity to .8 percent. The ALG automated production sector that is displayed by the Tambov Electroplating Equipment Plant yields an annual economic savings of 20,000 rubles. The lifting capacity of the manipulator is one half ton. The manipulator is controlled by the use of a command device based on contactless logic elements. The productivity of such a sector when applying electroplated coverings is 120; when applying chemical coverings the productivity is 150 square meters per hour.

During electric arc and contact welding of metal structures the manipulator increases labor productivity by 2 to 2.5-fold. New interesting designs are being demonstrated at the exhibition by the All-Union Designing Institute of Welding.

The L'vov association "Konveyyer" and the All-Union Scientific-Research Institute of Lifting and Transport Machine Building are becoming familiar with the MAK-type manipulators. They are designed to be used for unloading and loading a suspended conveyor without stopping. The MAK-1-50 simultaneously feeds manufactured articles weighing as much as 50 kilograms into a floor-model conveyor-storage unit, the feeder of the technological equipment or other means of transportation, and also in sequence places them on pallets or in packaging. The MAK-2-320 weighs or removes from a suspension member loads weighing up to 320 kilograms, while delivering them to the work place. The uniqueness of these manipulators is that they have a hydrodistributor which sends pulses for estimating the "steps" and which ensures the acceleration, braking and confinement at a given point. In this section of the exhibition we learn that in the Eleventh Five-Year Plan at the enterprises there will be a "family" of loading manipulators with a lifting capacity of 250 to 700 kilograms with an adapted control from a micro-computer.

It is the creation of industrial robots with elements of artificial intelligence that is now becoming one of the main trends in the automation of production. It is necessary to substantially expand the range of work of the robots. The exhibition demonstrates the need and opportunity of adopting them not only in industry but also in agriculture, construction, in transportation and in the non-production sphere of the economy. And another important task is being solved - the transfer to modular manipulators. Consisting of unique units and equipped with a selection of attachments, the modular manipulators can be used in combination with different equipment.

One of the display stands is devoted to the program that is being carried out to standardize automatic manipulators. The program will incorporate 54 standard-technical documents. It has been estimated that the introduction of the Unified technical requirements, unification and standardization will make it possible to reduce the cost by 2 to 3-fold and to speed up the time periods for developing new models of manipulators.

In the "Basic directions for the economic and social development of the USSR in 1981 through 1985 and up to 1990" it is written: "to develop production and provide for the extensive use of automatic manipulators (industrial robots), built-in systems of automatic control using micro-processers and micro-computers, to create automated shops and plants." The intersectoral exhibition of the best models of automatic manipulators will help to fulfill this important task more successfully.

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METALWORKING EQUIPMENT

CLOSER COOPERATION NEEDED IN DEVELOPMENT OF INDUSTRIAL ROBOTS

Moscow EKONOMICHESKAYA GAZETA in Russian No 13, 1981 p 6

/Article by A. Kondrashov: "The Robot Steps Into the Production Shops"/

> /Text/ The Basic Directions which were approved by the 26th Party Congress call for the development of production and for provision to be made to make extensive use of automatic manipulators (industrial robots). Many scitific-research institutes, design bureaus and scientific production associations participated in the practical solution of this task. ENIMS /Experimental Scientific Research Institute of Metal Cutting Machine Tools/ was called upon to make its contribution to this matter.

On the rack in the precision shop of ENIMS rest 160-kilogram metal "cigars" - the future shafts of electric motors. For now their unprocessed surfaces are turning black.

In the company with the chief of the institute's laboratory, V. Velikovich, we approach the production sector where three machine tools are serviced by one automatic manipulator. The laboratory chief after turning on the program control panel feeds a command to the robot. The robot moved along the monorail. Having reached the rack, the robot stopped. Having easily picked up a billet, it carried it to the lathe. After stopping, it returned, picked up the next shaft and proceeded smoothly to the next lathe.

While servicing the established third lathe, the first has already removed a layer of metal from the billet. The robot, without losing a second, took and returned to the processed shafts.

Equipped with an adaptive system that imitates a sense of touch, the automatic manipulator is "taught" to recognize parts and to measure them.

At the ends of the metal rack at a height slightly less than that of a man flash the figures. This was the programmed control panel - the "heart" of the robot, in which the spools of punched tape were previously fed.

"The UM-160 robot is our most tested model," explains the laboratory chief. "The production sector in which it is the basic actor has already been put into operation at the Moscow Dinamo Plant, where it processes shafts for electric motors."

Initially ENIMS designers came up with a model capable of taking billets, putting them in position and then removing them. Now there are differences from the first model. These differences have to do with improvement in design and increased possibilities of the robot. The manipulator has become more reliable. Gradually it is "assimilating" related skills, which it performs knowledgeably and, one might say, even with intelligence.

In the institute's laboratory and at the experimental Stankokonstruktsiya plant they are creating promising robot models. They are being assembled with metal cutting machine tools.

For the more recent models the institute has designed some rather clever though simple attachments. On the mechanical hand, just above the claws, they have installed four handles with crowns of teeth, or "moustaches" as they call them here. Infrared "eyes" have also been built in. The "eyes" are aimed in the direction of the machine tools. This is easily understood. For it is necessary to ensure the safe use of the robots.

To demonstrate the considerable potential of this technical vision, leading engineer V. F. Zhulanov gives a command to the manipulator. The manipulator starts to move along the 18-meter long monorail. But suddenly without any assistance it comes to a halt. It turns out that a foreign object has shown up within the zone of vision. In violation of all safety rules someone intentionally reached toward the part being processed just as the mechanical hand was preparing to replace the billet. The infrared glance, having encountered an unfamiliar object, reacted immediately. The mechanical hand made no further movement.

The question might be asked: "But the infrared ray is probably affected by the parts of the machine tool - the spindle, the rear chuck and the housing. Why then does it not issue a false command to stop?" The answer is that the technical vision was designed so that the length of the infrared ray can be controlled in accordance with the situation. In this case it did not exceed a meter.

A brief stoppage will occur if the handles touch some object. In the memory of the manipulator there is a red light that flashes as in a stop light that says "stop". Special devices developed at ENIMS also ensure the correct execution of commands, measurement and quality control of parts.

There is no need to design each model of automatic manipulator from scratch. The switch from diversity to future, optimal series of robots is now being completed. With the use of a minimal number of robots it is necessary to perform as many operations as possible. This

results in the greatest economic effectiveness; the cost of the manipulators is recovered rather quickly.

The principle of expediency has forced the ENIMS scientists and other scientific-research organizations to search for ways to develop special designs which cover a specific field of application (the so-called target industrial robots). Machine tool models are selected which are similar in the operations that they perform when placing billets in the working zone and removing finished parts. On this basis manipulators for servicing specific groups of metalworking units are now appearing.

Of course, all of this requires the modernization of the equipment that is used to assemble production sectors with robots. Even today models of semi-automatic machine tools are being manufactured without being equipped to handle the automated loading of articles. For this reason in the industrial robot department of the institute I was told that frequently the machine building plant-customer must create its own link-up between the manipulator and its equipment.

ENIMS has created a single modification of automatic manipulators, but with different lifting capacities. They have presented the UM-160 and its younger "brothers", which are adapted to service machine tools which manufacture parts weighing from 10 to 40 kilograms.

Candidate for the degree of Doctor of Technical Sciences V. G. Ostapchuk was "teaching" an automatic manipulator to sort piles of parts when we found him. This was an adaptive industrial robot, the UM-40F2, which is one of the most promising new models. It most fully responds to the requirements of automated production. Here is why.

To create a robot that can select the needed part from a pile of billets lying in a crate it is not enough to just simply program movements. The model UM-40F2 manipulator is equipped with transducers and a computer-based control system. At the end of the mechanical hand we have installed a claw with a calibrated magnetic field. This means that the "fingers" will pick up only the needed billet.

In the socialist pledges of the Moscow workers for the current year it says in one place that the ENIMS collective is obliged in addition to its research plan in cooperation with the Krasnyy proletariy plant to create at this enterprise an automated production sector with numerically controlled machine tools that is serviced by an industrial robot. This will double labor productivity.

At present at the institute they are beginning to assemble this production sector. The numerically controlled devices have been built directly into the machine tools rather than being installed in separate racks. During the process of manufacturing parts a worker can simultaneously make program adjustments and achieve a high degree of precision by pressing on specific computer keyboards. The machine tools and the manipulator interact in a "dialog" mode.

The machine tools are serviced by a robot with a lifting capacity of 40 kilograms. With the help of the robot the shafts undergo a complete surface processing on each unit.

"When building automatic manipulators we start by developing the prerequisites for the manufacture of robot-assisted equipment sets," explains the director of ENIMS, V. S. Vasil'yev. "These sets will incorporate semi-automatic machine tools, manipulators and auxiliary devices which provide the link between the equipment set and the rest of the production facility."

The concepts of "teaching" robots a series of functions that are now performed by machine tool mechanisms are coming into their own. For example, its association with the processing center (multi-purpose unit, combining the capabilities of several machine tools) will make it possible to entrust the manipulator with replacing the cutting tools. Not only will it place the parts in position, it will also clean them with a stream of liquid or air and make measurements.

Everything that we are discussing will come to pass in the ve y near future. It is necessary to establish closer contacts and creative ties between the scientists and designers who are creating the industrial robots and the related-suppliers of control systems and transducers, high-energy drive shafts, high-pressure hoses and other assembly articles. May the robots reach the shops of the industrial enterprises as quickly as possible.

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METALWORKING EQUIPMENT

EQUIPMENT REPAIR COSTS DISCUSSED

Moscow TRUD in Russian 14 Feb 81 p 2

[Article by I. Kragel'skiy, chairman of the VSNTO [All-Union Council of Scientific-Technical Societies] Committee on Problems of Wear-Resistance and Friction, doctor of technical sciences, professor: "Billions of Rubles for Repair"]

[Text] Each year we spend billions of rubles for the repair of machinery and equipment. In the machine-building and metallurgical industries one in five workers is a repairman.

Statistics show that more than half of all breakdowns and equipment downtime caused by malfunctions is brought about by wear in moving parts of machinery. A comparatively new science --triboengineering-- is devoted to the study of the reasons for this and the nature of friction and wear of solid bodies.

In recent years Soviet scientists have created a reliable and effective methodology for raising the reliability of these units. But, unfortunately, far from all of the scientists' practical proposals and recommendations have been put to use. For example, Soviet scientists have developed a methodology for protecting a metal-cutting tool from wear by using special coatings. When working on alloyed steels,common cutters and drills wear very quickly. Sometimes they have to be replaced every ten minutes. A thin-- measured in several microns --covering made of titanium nitride increases the tool's service life 1.5-to 10-fold; and labor productivity increases by several times when using such a tool. A special installation called the "Bulat" has been created which can be used to apply a protective layer on a cutting tool in conditions of any metal-working enterprise. This installation has been demonstrated in the Soviet Union and abroad and has been well received by specialists. But the manufacture of these installations is not meeting demand.

Six years ago at the Institute of Machine Studies of the USSR Academy of Sciences they came up with a scale for evaluating the wear-resistance of machine units and parts. This scale makes it possible to predict the reliability of units and parts and the effectiveness of design solutions. As concerns existing equipment, the scale of wear-

resistance would to a great extent make it possible to regulate the manufacture of spare parts and to avoid a situation in which some spare parts are under-produced and others are over-produced. On a national scale we are talking about millions and millions of rubles which can be saved and used for the needs of the national economy.

Unfortunately, this scale still has not been approved by the USSR State Committee for Standards and is not the law.

For the centralized adoption of scientific achievements an appropriate state working organ is needed - a state service to deal with wear. Such a service would have the same rights as the state metrological service. Apparently it would have to function under the USSR State Committee for Standards because the requirements for wear-resistance will be adopted at enterprises in the form of a system of state standards.

In connection with this I propose making the following addition to the draft of the Basic Directions. In Section IV in the paragraph beginning with the words "raise the technical level and quality of machine building product..." add the following sentence: "Ensure the effective adoption of new materials and lubricants and design workups which increase the wear-resistance and reliability of machine units and parts."

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BRIEFS

ROBOT FROM ODESSA--Labor productivity will be significantly increased in processing the shaft of an automobile transmission by a new machine tool that has an automatic manipulator. The machine tool is manufactured at the Odessa Machine Tool Building Production Association and recently shipped to KamAZ /Kama Truck Plant/, where it will be incorporated in one of the automatic production lines. With the use of the manuipulators the "sam" machine tool can place billets, change work modes and tools and transfer the manufactured article along the technological line. /Text/ /Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 17 Feb 81 p 2/ 8927

HIGH PRECISION MACHINE TOOLS--An experimental model of a high precision centerless cylinder-and-cone grinder has been accepted by the state commission at the Vitebsk plant imeni Kirov. It is one representative of a new line of machine tools of this type. There will be 8 base models and 27 modifications in the line. They are to be used in the instrument building, watch and tool building industries. The productivity of the new units will be increased in comparison with those now being produced by 1.6-fold. The relative use of metal per unit of capacity will be reduced by nearly half. /Text/ /Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 8 Feb 81 p 2/ 8927

ROBOT TRANSPORTER--Industrial robots tirelessly place billets on machine tools, remove them and put them in packages. But how do the billets get there and how do the finished parts get to the warehouse? By using a conveyor? That is expensive. Specialists from the Experimental Design Bureau of Technical Cybernetics of the Leningrad Polytechnical Institute have developed the MP-12T robot-cart for this purpose. The unit contains two "baskets" which can accomodate five boxes of parts each. There is also a compartment for the battery. A mechanical "hand" has been installed on the top, which loads and unloads the boxes. The robot moves about the shop on tracks, which have been "designated" under the floor by a belt conductor. But contact with the machine tools and equipment is maintained without wires by using electrooptical transducers. The use of the robot-carts makes it possible to free up to 60 men during a two-shift work period. /Text/ /Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 5 Mar 81 p 4/ 8927

MP-100 ROBOT--When, for example, it is neccesary to place a heavy billet on a machine tool which will be worked on for a long time, there is no need for programmed control. The most important thing is that the manipulator has electrical or other "muscles" to do the heavy work. They can be controlled by a man using a handle at the end of a mechanical "hand." These thoughts have helped the specialists at the NIAT /Scientific-Research Institute of the Aviation Technology/ to create the MP-100 electromechanical loading manipulator. Subordinate to a man's hand, the MP-100 can lift parts weighing as much as 100 kilograms to a height of 1.5 meters. /Text/ /Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 5 Mar 81 p 4/ 8927

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